EXECUTIVE SUMMARY

Early Deployment of ATMS/ATIS For Metropolitan Detroit

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Rockwell

Autonetics Electronic Systems Division
Rockwell International Corporation
3370 Miraloma Avenue
Anaheim, California 92803-4192

Dunn Engineering Associates

HRC
HUBBELL, ROTH & CLARK, INC

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Background

The Michigan Department of Transportation (MDOT) is currently planning for the expansion of their current Advanced Traffic Management and Advanced Traveler Information Systems (ATMS and ATIS, respectively). Current ATMS and ATIS coverage include 32.5 freeway miles surrounding metropolitan Detroit and an additional 212 freeway miles of coverage is in the planning stages,

In order to aid MDOT in assessing deployment strategies for the expansion of freeway coverage, MDOT contracted Rockwell International and its subcontractors Dunn Engineering Associates and Hubbell, Roth, and Clark, Inc. to conduct an engineering study and to provide guidance in the Early Deployment of ATMS/ATIS technologies within metropolitan Detroit. Studies conducted by Rockwell International to assess appropriate technologies, architectures, and deployment strategies for the expanded area of coverage.

Established and promising new technologies are assessed to maximize system efficiency and minimize costs (installation, operating, and maintenance). System components such as controllers, sensors, communications, and information dissemination systems are evaluated to determine compatibility with the overall system architecture. The system architecture follows an open architecture model which provides MDOT the capability to use standard commercial-off-the-shelf (COTS) system components.

In addition to technology assessments, the Early Deployment project analyzes area traffic congestion to determine corridor priorities. This assessment is used in aiding in the development of implementation plans and to identify which freeway corridors or segments warrant immediate ATMS/ATIS deployment to reduce congestion and improve traveler safety.

Introduction

The objective of the Early Deployment study is to provide MDOT with an ATMS/ATIS system that assists MDOT to reduce congestion, increase traveler safety, and enhance incident management activities. Use of existing infrastructure and system components are used to reduce initial costs and minimize system deployment time. A unique deployment strategy is also recommended to allow incremental deployment

The Early Deployment Study report is segmented into the following sections and specific engineering analysis details are also provided

<u>Technology And Architecture Analysis</u>
Section 1 - Introduction
Section 2 - Technological Analysis
Section 3 - Priority Corridor Analysis
Section 4 - System Architecture Description
Section 5 - Engineering Design for Deployment

<u>Incident Management</u>
Volume I - I-75 Corridor Incident Management Plan
Volume II - Incident Management User's Guide

The technology and architecture analysis document consist of over 300 pages of technology assessments, corridor deployment analysis, architecture definition, and engineering design for deployment The incident management volume documents techniques and processes needed for successful incident management and response planning.

I. Technology and Architecture Analysis

Trade Analysis

Standardized evaluation criteria scoring were maintained as much as possible for sections that used detailed technical trade analyses. Assessments were made on a scale of one to ten where ten denotes favorable compliance and one is noncompliant. The score represents the degree to which the evaluated item satisfies each of the trade criteria. Table 1 shows the complete definition of the scale.

Table 1. Evaluation Assessment Guidelines

Level of Compliance	Score	Assessment Guide
Exceeds Compliance	10	Fully satisfies and clearly exceeds requirements in all areas
Fully Compliant	9	Satisfies requirements in all areas with wide margin
Good Compliance	8	Satisfies minimum requirements with moderate margin
Above Average Compliance	7	Satisfies minimum requirements, some margin
Average Compliance	6	Satisfies minimum requirements, questionable margin
Minimum Compliance	5	Satisfies minimum requirements, no margin
Marginal Compliance	4	Marginally satisfy minimum requirements (<100%)
Partial Compliance	3	Partially satisfy minimum requirements (<75%)
Poor Compliance	2	Satisfies less than 50% of minimum requirements
Does Not Comply	1	Less than 25% of minimum requirements

Evaluation Criteria Weights

To further optimize trade study findings, weighting factors were applied to each of the evaluation criteria based on their relative importance to the objectives. The weights are given a value of one to ten as defined in Table 2.

Table 2. Weight Factor Guidelines

Weight Factor	Weight Factor Rationale Guide	Need Type
10	Criterion is critical to satisfying requirements	Mandatory
9	Criterion is essential to satisfying requirements	Mandatory
8	Criterion is needed to satisfying requirements	Mandatory
7	Criterion is somewhat needed to satisfying requirements	Mandatory
6	Criterion contributes to satisfying requirements, but is not needed	Mandatory
5	Criterion is strongly desired; considered as a potential requirements or enhancement	Optional
4	Criterion is desired, considered "nice to have"	Optional
3	Criterion is moderately desired	Optional
2	Criterion is somewhat desired	Optional
1	Criterion is neutral	Optional

Summary of Findings

Technological Analysis

Technology assessments are conducted for major Advanced Traffic Management System (ATMS) and Advanced Traveler Information System (ATIS) components. These assessments evaluate key functional and non-functional (i.e. installation cost, aesthetics, operating & maintenance cost) characteristics which effect deployment strategies. Weight factors are applied to each key requirement and analyzed based on their capability to satisfy the requirements. System components evaluated are:

- Traffic Sensors
- Video Surveillance
- Control and Data Processors
- Traveler Information Diisemination
- Communication Systems

Table 3 summarizes findings from the technological analyses. Each system component was subjected to technical performance and life cycle cost analyses. Recommendations were based upon the early deployment criteria of providing quick, visible, and measurable results to enable metropolitan Detroit motorists to quickly benefit from the ATMS/ATIS system.

Table 3. Technological Analyses Summary

ATMS/ATIS Component	Recommended Technology	Comments
Traffic Sensors	Machine vision sensors in conjunction with inductive loop detectors	• Quickly deployable • Attractive life cycle costs • Expandable • Less system maintenance
Video Surveillance	Dual camera - low light B&W and high definition daylight color	• Provides around the clock coverage • Enhanced image definition in low light and night applications • Compatible with *FAST-TRAC* video surveillance system
Control and Data Processors	Modular system components using a standardized backplane	• Similar to up-coming Caltrans 2070 • High level programming language and software development environment • Non-proprietary solution • Multiple vendor support • Upgradeable and expandable
Traveler Information Dissemination	Changeable message signs (CMS) and highway advisory radio (HAR)	• Quickly deployable • Visible deployment • No cost to travelers • Uses existing control system (CMS)
Communication System	Area wide radio system (Digital Data) Microwave Communications (Video images)	• Low installation cost • Quickly deployable • Utilizes available MDOT frequencies • Provides migration path to other medium as they become available (i.e. fiber optics) • Can he used to "leap frog" to other deployment corridors as the system migrates to other mediums

Priority Corridor Analysis

The identification of priority corridors aids in determining which freeway segment in metropolitan Detroit require initial deployment of advanced traffic control components. The analysis evaluated various demand and capacity characteristics for each corridor segment and relative deployment rankings were developed.

The highest priority corridor is also used to acquire measurable effects of traffic conditions once the advanced system is deployed. Although not a primary requirement, segments adjacent to existing monitored freeway segments were considered to allow a "before and after" analysis to be performed. The results from this analysis will provide the means to measure the effectiveness of the advanced traffic control and information dissemination system. The results can be used to enhance control schemes in order to acquire maximum benefits for the remaining freeway segments.

Corridor Identification

Corridors that were listed in various strategic planning and request for proposal documents were initially used in identifying corridor segments. Results from initial analysis indicated that there was a potential that the original thirteen (13) segments did not provide complete coverage of the entire 250-mile freeway system in metropolitan Detroit Also, the corridor along I-75 from I-94 to Pontiac was too long in relation to other corridors being evaluated

As a result from the initial assessment, nineteen (19) corridor segments were evaluated rather than the initial thirteen. The I-75 corridor was split in to at 9 Mile Road and five additional corridor segments were added to the evaluation process. The additional five corridor segments include the currently instrumented freeway system. The most significant segments added were the Lodge Freeway (M-lo), Greenfield to Jefferson, and the Ford Freeway (I-94) between Wyoming and Moross.

Priority Corridor Recommendation

On the basis of the results from the analysis, the I-75 corridor from I-94 to 9 Mile Road is determined to have the highest priority for ATMS/ATIS early deployment It is recommended that this segment be identified as the initial deployment corridor.

This priority corridor is also adjacent to the existing instrumented freeway system. It is recommended that statistical traffic congestion and occupancy data be recorded prior to deployment of the initial system. After the deployment is complete and operational, statistical data should again be collected to determine the effectivity and performance of the ATMS/ATIS early deployment system. The difference between the "before and after" data can also be used to enhance control strategies to improve system efficiency.

However, this recommendation does not preclude spot deployment of other intermittent high demand areas which result from recreational travelers such as the area surrounding the Silverdome Stadium in Pontiac or at Metro Airport. To aid travelers in these areas, partial deployment of video surveillance and highway advisory radios (HAR) can be used to monitor and inform travelers of traffic conditions before and after special events or at times of high seasonal commercial air travel. Table 4 lists the corridor priorities in order. There is a potential that lower priority corridors may be deployed earlier in order to maximize deployment costs.

Table 4. Relative Ranking of Priority Corridors

Priority Ranking	Corridor Segment
1	I-75 (I-94 to 9 Mile Road)
1	I-7.5 (I-94 to I-375)
2	I-696 (US 24 to I-75)
2	I-94 (Wyoming to Moms)
3	I-696 (I-75 to I-94)
4	I-696 (I-96 to US 24)
5	I-275 (M-16 to M-102)
6	I-96 (I-75 to I-275/M-14)
7	M-10 (Greenfield to I-696)
8	I-75 (9 Mile Road to Pontiac)
9	M-39 (I-75 to M-10)
10	M- 10 (Greenfield to Jefferson)
10	Davison (M- 10 to I-75)
11	**I-375**
11	I-94 (Morass to M-19)
12	I-94 (Wyoming to I-275)
13	I-75 (I-96 to I-275)
14	I-275 (I-75 to I-96/M-14)
15	M-59 (BR-24 to M-53)

System Description / Architecture

The initial deployment architecture is designed to support a modular, flexible, and open architecture. Three key characteristics of the architecture are maintained to assure compatibility for future system components. These characteristics are:

- Distributed Modular Design
- Defined Interface Protocol
- Standardized Electrical Interface

Figure 1 shows the top-level system architecture and identifies early deployment system components. Maximum use of existing system resources enables quick deployment and reduces the cost of deployment. The following three subsections describe benefits from the use of key characteristics identified above.

Distributed Modular Design

In order to maximize system flexibility and incremental deployment strategies, a modular architecture with standardized interfaces is recommended. Each system component should be treated as an independent node capable of operating autonomously whenever possible. Distributing the functionality to the lowest level component significantly reduce communications requirements. Cost effective processing platforms are available as commercial-off-the-shelf (COTS) items. Using COTS components eliminate custom and proprietary hardware solutions.

A hierarchical system design can also be designed to provide autonomous regional control and to reduce single point failures. A regional processor can be deployed to coordinate a specific region and operate without continuous interaction with the main system host computer. This design allows regional segments to continue operations even if the main host system goes down Also, if a regional segment loses primary power, other regions within the system can continue to operate.

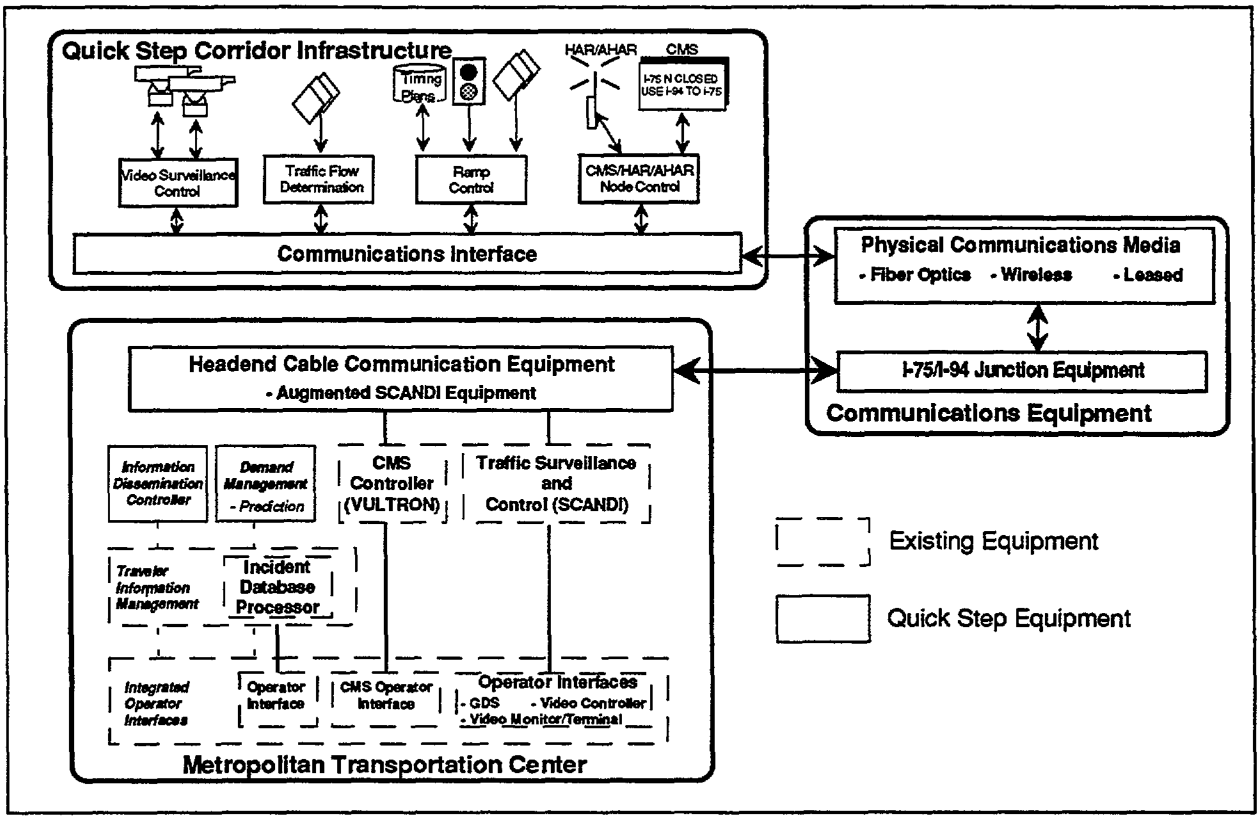

Figure 1. Top-Level System Architecture

The modular design concept inherently provides the capability to expand the system with minimal hardware and software modification. The architecture allows system components to be incrementally added as the area of coverage increases. Additional functionality can also be added if required (i.e. temperature sensors, weigh-in-motion (WIM), lane control, etc.) provided that the increase in data transmission does not strain the installed communications system. In such cases where the installed communications cannot accommodate the increase in data traffic, the modular architecture allows multiple communications systems to operate simultaneously or allows the overall communications system to be upgraded without affecting system operation and performance.

Interface Protocol

An interface protocol that supports unique node addressing allows each node to be addressed individually. The message structure and content can be generically specified with functional identifications imbedded within the message content. In other words, the message header that includes a node address, function identification (detector station, ramp metering, HAR, CMS, etc.), and message length can be used as a message prologue. Message contents can vary depending upon the function identification. For example, the message content for a CMS function can contain the specific message to be displayed, or for ramp metering functions, the message content can contain ramp metering parameters. By designing the protocol in a generic manner, system compatibility is retained as new technology functions are added in the future.

To effectively use a generic protocol as described above, individual nodes must have sufficient processing capabilities to execute required functions. Required functions include protocol/message handling, message parsing and prioritization, function execution, and input-output manipulation.

Standardized Electrical Interface

The use of standardized electrical interfaces, such as EIA-232, EIA-422, or EIA-485, at processing nodes enables COTS communications interface modules to be used where requimd. Such communications modules may include radio modems, terminal node controllers (TNCs), fiber optic converters, and data multiplexers. This design feature provides the capability of technology migration as they mature. Radio modems can be used until migrating onto a fiber optic system or low power processor units can be upgraded to higher powered units as required.

An additional benefit from standardized interfaces can be realized in the development of system component procurement specifications. ATMS/ATIS components can be specified at the functional level as long as the subsystem interface is standardized For example, a CMS node can be functionally specified to have the capability to remotely program message contents. With a standardized interface such as EIA-232, the CMS can be integrated to the ATMS/ATIS by using radio modems, cellular telephone, or connected via spare serial port of a ramp detector station. It should not be a requirement for the CMS subsystem to have all of the functional requirements incorporated into a single unit. It may be required that a particular CMS unit be controlled by a single board computer with a serial port. Some CMSs only operate with a local keypad or dumb terminal With the addition of a single board computer and application software, the CMS subsystem can now support the generic protocol, store messages in local memory, or operate autonomously if connected to a regional processor which monitors a group of detector stations.

Standardized interface also provides the capability to allow external agencies such as Road Commission for Oakland County (RCOC) to monitor freeway traffic conditions. The information can be used to adaptively adjust arterial signal timing to minimize travel delays for individuals entering the freeway system. The information can also be used to notify travelers of freeway traffic conditions prior to entering the freeway system from arterial streets.

Engineering Design for Deployment

Various analyses are conducted to determine deployment costs, deployment contracting methods, and deployment schedule. Cost estimates for each corridor are identified and a benefit/cost analysis was conducted. Results indicate that a benefit/cost ratio of over 4:1 can be realized once the whole system is deployed.

Corridors identified in Section 3 are analyzed and compared to construction schedules and benefit/cost ratios for each corridor. From these attributes and characteristics, a recommended deployment schedule was created. Various system procurement techniques are also analyzed to determine the most cost and schedule effective means of deployment. As a result of the analysis, a design-build procurement approach is recommended to minimize deployment risk and to maximize system procurement efficiency and management.

II. Incident Management

The Early Deployment Study also requires the contractor to develop:

- A model for preparing a detailed incident management plan
- The test and validation of the model on a specific freeway segment and
- A Comprehensive Incident Response Plan

The incident management portion of this study is divided into two separate documents; ***Volume I - Z-75 Corridor Incident Management Plan (IMPLAN)*** and ***Volume II - Incident Management User's Guide.***

Methodology

A. Model

To develop "a model for preparing a detailed incident management plan," a software "shell" was developed by ***Dunn Engineering*** Associates. ***This shell*** contains a ***generic*** incident management plan which consists Of:

- generic text which describes incident management, and the reasons for implementing an incident management plan
- a text framework which establishes a generic incident management plan
- an extensive series of tables

The shell serves as the model. By filling in the series of tables with information relevant to the specific area or region, ***the*** user generates a ***site-specific*** incident management plan. The text framework refers to these tables. As a result, when the tables are completed, a site-specific incident management plan is generated. Volume II provides specific guidance on completing the incident management plan

B. Test and Validation

The model termed IMPLAN, was then applied to the I-75 Corridor between I-94 and Adams. This activity was led by Hubbell, Roth, and Clark with active participation by the I-75 Administrative Traffic Management Team. The latter has endorsed the result, approved at a meeting on April 29, 1994. The reasons for selection of the I-75 Corridor to test and validate IMPLAN are provided in the Technology and Architecture Analysis portion of the Early Deployment Study.

C. Comprehensive Incident Response Plan

The Comprehensive Incident Response Plan consists of a plan to establish alternate routes in the event of an I-75 closure. These mutes are depicted in Volume I of the Incident Management Plan

Intended Audience

The Incident Management Plan generated by IMPLAN is targeted to personnel involved in incident management. This includes affected agencies including:

- State DOT
- Counties
- Cities
- Smaller local jurisdictions
- Police
- Fire
- EMS
- Media
- Third party Traffic information providers

An important aspect of the plan development is to specifically identify the agencies which contribute to incident management in a particular area or corridor.